Nov. 14, 1961 B. L. SITES ET AL 3,008,242

RADIANT ENERGY MEANS FOR INDURATING MATERIALS

Filed Oct. 11, 1957

Fig. 1

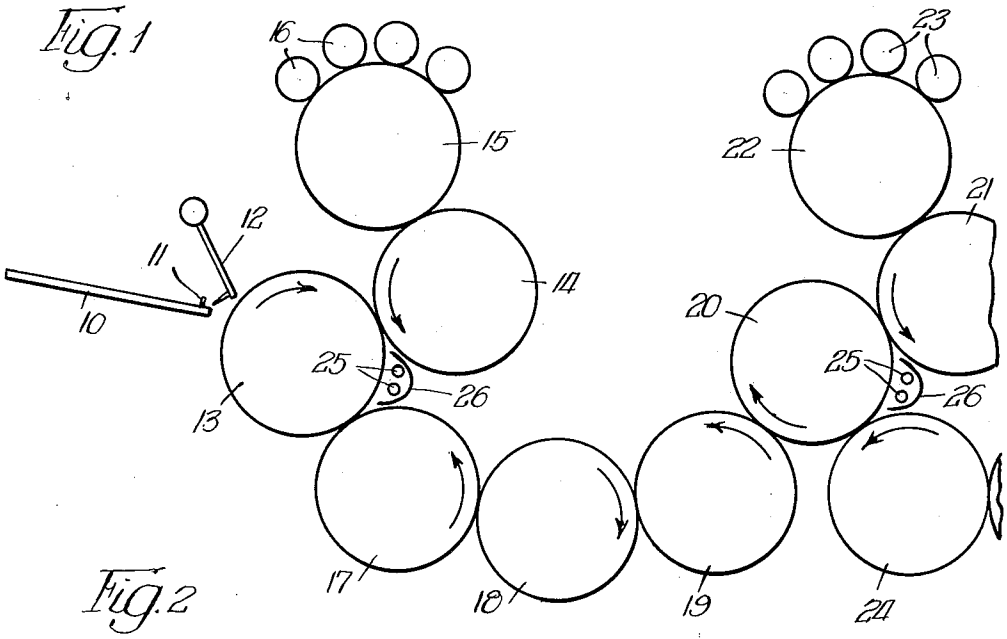
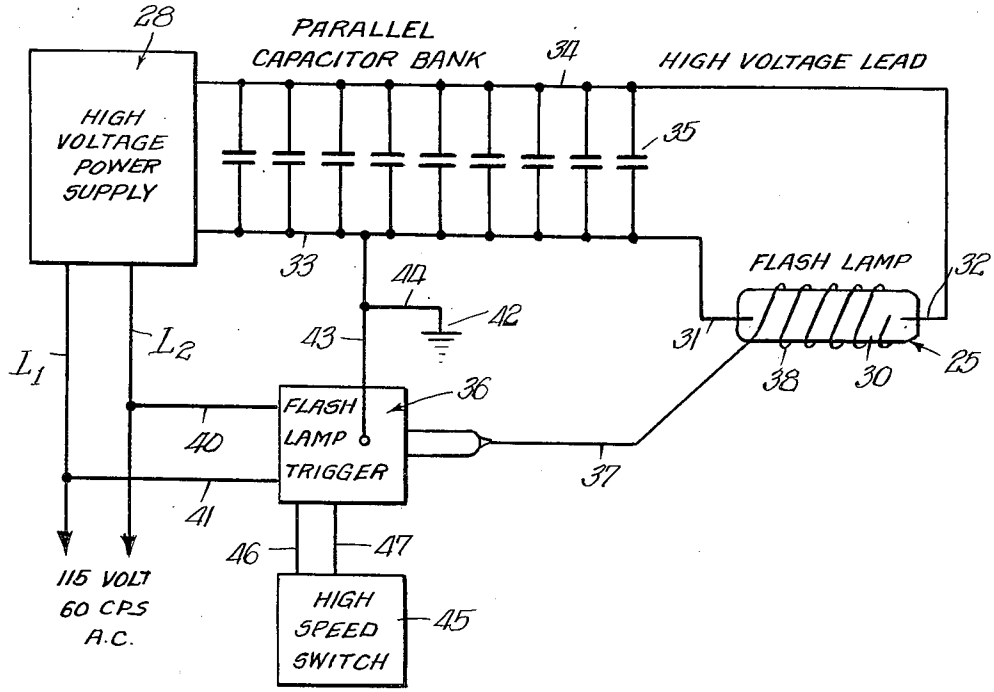


Fig. 2



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United States Patent Office 3,008,242 Patented Nov. 14, 1961

3,008,242
RADIANT ENERGY MEANS FOR INDURATING MATERIALS

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Filed Oct. 11, 1957, Ser. No. 689,721
4 Claims. (Cl. 34—1)

The invention relates to a method and apparatus for indurating materials such as film forming or coating compounds, either aqueous or non-aqueous, and has reference more particularly to improved apparatus for drying and hardening relatively thin films of such compounds substantially instantaneously with their application to a backing web, printed sheet or other suitable supporting medium.

The invention has application to all film forming or coating operations wherein a thin film is involved and said film may be either continuous or intermittent, and either unsupported or having a temporary or permanent support comprising a web of paper or plastic or said support may consist of a silk screen, a paper sheet or similar backing material of this nature. For high speed production purposes it is desirable to achieve a rapid drying and hardening of the film immediately following its formation or application and this is absolutely essential in the printing industry in order to prevent offsetting of the inks. For such purposes it has been customary to add drying oils or other quick setting compounds to the coating solutions and in connection with printing inks, vehicles have been prepared for the same containing photopolymerizable ingredients, or, in other words, ingredients responsive to light of certain limited wave lengths and which has the effect of triggering and accelerating the polymerizing reactions to cause the thin ink films to dry at a much faster rate than would otherwise be the case.

In view of the foregoing, an object of the invention resides in the provision of apparatus incorporating improved electromagnetic radiating means having the ability to emit pulses of energy as a form of continuous spectra, and the invention contemplates the utilization of the same as an accelerating agent in the hardening and drying of special coating compounds following their formation as unsupported thin films or application as thin films to sheets or webs of material such as paper or other suitable supporting means.

Another object of the invention is to provide novel and improved apparatus consisting essentially of a flash lamp and a triggering circuit for flashing the lamp to thereby produce pulses of radiant energy of a continuous nature or spectrum and which has utility in accelerating the hardening and drying of special film forming compounds with particular applicability to printing inks, whereby relatively thin ink films can be dried substantially instantaneously to prevent offsetting onto transfer cylinders, for example, or onto adjacent sheets when in stacked relation on the delivery table.

Another and more specific object is to provide apparatus as described for accelerating the hardening and drying of photopolymerizable coating compounds and in particular, printing inks containing such polymerizable ingredients in order to prevent offsetting of the inks as described, and to achieve a high energy release as regards the emitted rays the lamp is flashed using a bank of condensers, the capacity of which may be varied to vary the duration of each flash and wherein the triggering circuit is controlled through a high speed switch so that the number of flashes per second can also be varied.

Another object of the invention resides in the provision of apparatus such as described wherein the source of radiant energy, namely, the flash lamp, is located in close proximity to the print receiving surface and wherein said radiant source is characterized by its ability to emit pulses of energy in the form of a continuous spectrum and which is higher in energy, measured in joules, than the discontinuous or line spectrum. Accordingly, the light rays emitted by this source, trigger and accelerate the polymerization reactions between the ingredients of the ink so that the combined action of the high energy continuous spectrum light is to effect an instantaneous hardening and drying of the ink films even to the extent of preventing any offsetting of the ink at maximum printing speeds.

With these and various other objects in view, the invention may consist of certain novel features of construction and operation, as will be more fully described and particularly pointed out in the specification, drawings and claims appended hereto.

In the drawings which illustrate an embodiment of the invention and wherein like reference characters are used to designate like parts—

FIGURE 1 is a diagrammatic end elevational view showing the various cylinders of a two color offset press and which additionally illustrates the location of the flash lamps in accordance with the present invention for indurating the printed matter; and

FIGURE 2 is a diagrammatic wiring circuit showing the various elements making up the ink drying unit for attachment to printing presses.

A multi-color offset press has been selected as the preferred mechanism for explaining the invention and accordingly FIGURE 1 discloses in diagrammatic form the various cylinders of such a press and illustrates their mode of operation. The sheets of paper to be printed are supplied to a registering table 10 and following a registering operation, effected by the registering guides such as 11, the sheets are individually transferred by gripper transfer mechanism 12 to the impression cylinder 13 of the printing couple consisting of said cylinder 13 and the blanket cylinder 14. The plate cylinder 15 carries a printing plate which is suitably inked by means of a plurality of inking rollers such as 16. Accordingly, the plate cylinder 15 transfers an inked impression to the blanket cylinder 14 and on each revolution, as a sheet of paper passes between cylinders 13 and 14, the same is printed since the inked impression from cylinder 14 is transferred onto the outer exposed surface of the paper sheet as it passes between the printing couple. The cylinders 17, 18 and 19 are transfer cylinders and the same operate to transfer the sheet from the impression cylinder 13 of the first-color printing unit to the impression cylinder 20 of the second-color printing unit. Cylinder 20 in combination with the blanket cylinder 21 comprises a printing couple similar in all respects to 13 and 14 and the blanket cylinder of said printing couple has contact with a plate cylinder 22 and which also carries a printing plate to which ink is applied by the inking rollers 23. The sheet of paper being printed in passing between cylinders 20 and 21 has a second inked impression of a different color applied thereto, whereupon the sheet is taken by the transfer cylinder 24 and transferred to a third-color printing unit or other mechanism for different operations thereon, depending on whether the sheets are to be printed in two, three or more colors.

In accordance with the invention, coating machinery for applying their films to paper or other supporting mediums as exemplified in the offset press herein described may be equipped with apparatus for hardening and drying the film substantially simultaneously with its application to the paper sheet so that when the printed surface of the sheet is in contact with the surface of the first transfer cylinder, such as 17 or 24, it will not offset onto

said transfer cylinder nor will it be possible to smear the printed surface or effect any offsetting even at the highest speeds of the press. As shown in FIGURE 1, the apparatus essentially consists of one or more lamps as a source of radiant energy, indicated by the numeral **25**, and which are located in close proximity to the print receiving surface and immediately following the application thereto of the ink impressions from the blanket cylinders **14** and **21**. The lamps **25** are suitably backed by a metal guard such as **26**, the inside surface of which is constructed in a manner to reflect the light rays onto the inked surfaces of the printed sheets. The lamps are electrically connected to a source of high voltage direct current and triggering means are provided for flashing the lamps at a controlled frequency. Apparatus of this nature is shown in FIGURE 2, which will now be described.

The terminals L_1 and L_2 have connection with an alternating current supply source of the standard 110–115 volts and 60 cycle frequency. The numeral **28** represents conventional transformer and converter mechanism which functions to increase in various steps the voltage of the alternating current to approximately 4000 volts and to convert the same into direct current at this high voltage. In other words, the member **28** will supply the high voltage direct current for energizing the lamps and the same may be adjustable for supplying a direct current through a voltage range from 500 volts to 4000 volts in suitable steps.

The lamp **25** consists of a closed tube or envelope **30** which is made of fused quartz and said envelope contains an inert gas such as krypton or xenon under pressure. There may be added a small amount of mercury to the envelope for added intensity. The terminals **31** and **32** project from opposite ends of the lamp and the same have electrical connection by means of conductors **33** and **34** with the high voltage direct current source identified by numeral **28**. A plurality of condensers **35** are connected between the conductors **33** and **34** and in parallel with the lamp **25**. During operation, the bank of condensers **35** is charged up to full capacity by the high voltage direct current supply and upon discharge the said condensers supply an instantaneous surge of extremely high energy to the lamp and as a result thereof the energy emitted by the lamp upon flashing thereof is materially higher than would otherwise be the case. Also this type of lamp may be adjusted to emit light having a continuous spectrum and more efficient use can be made of this higher energy than that obtained from a discontinuous spectrum or line spectrum type of light. Accordingly, the lamp derives its value and utility from the continuous spectrum it emits when flashed.

As regards the wave lengths of the light emitted by the lamp **25**, it will be understood that light having wave lengths both in the infra red and in the ultraviolet range may be included and of course wave lengths of some or all of the light in the intermediate visible spectrum may also be included. Ultraviolet light having wave lengths ranging from 4000 angstroms, for example, to a lower limit of approximately 1800 angstroms, which is the limit for the transmission of ultravoilet light through quartz, are particularly desirable for the purpose of the present invention and the light source of the type described is particularly efficient in producing an abundance of light between these wave lengths.

The numeral **36** indicates triggering mechanism for the lamp **25** and the same is connected to the lamp by the conductor **37** which in turn is electrically connected to the trigger lead **38** located around the envelope **30** of the lamp. The leads **31** and **32** impress a threshold ionization of the gas in lamp **25** insufficient for discharge. The lead **38** upon energization will cause sufficient ionization of the gas in lamp **25** effecting a discharge of the condensers and an instantaneous flash of the lamp. The triggering mechanism **36** is suitably connected to the alternating current power source by the conductors **40** and **41** and the mechanism is likewise grounded as at **42** by conductors **43** and **44** which additionally ground the negative conductor **31** of the high voltage direct current power supply.

The invention contemplates that the lamp **25** will be flashed at a controlled frequency and accordingly the apparatus of FIGURE 2 includes a high speed switch generally designated by numeral **45** and which is electrically connected to the triggering mechanism **36** by the conductors **46** and **47**. The high speed switch may be operated from the press so that the unit will be fully automatic and accordingly when the press stops the high speed switch will likewise stop. The flashing rate of the lamp **25** is determined by the total time available for irradiation and the specific requirements of the film undergoing radiation. Also, there are many variables in connection with the operation of a press or other coating machinery which must be taken into account in selecting the flashing frequency for the lamp. For offset printing press operation the frequency will average from 60 to 80 flashes per second with a maximum of approximately 120 flashes per second. The length of time for each flash will depend upon the amount of the capacitance supplied by the bank of condensers. For a capacitance of approximately 25 microfarads the flash will exist for approximately 50 micro-seconds, whereas, for a capacitance of 1300 microfarads, the flash may exist for 2600 micro-seconds.

In accordance with the invention, a lamp having a high energy output is required to set the ink, in the restricted time permitted, limited by the design of modern high speed presses. This can be accomplished only by lamps which emit energies in intermittent flashes, rather than through continuous glow due to the fact that the stored energy can be built up to suitable higher levels before it is released through the lamp. A steady glow lamp once started emits energy continually but at considerably lower intensity levels. Therefore, in the exposure obtained, that is, the product of intensity and time, great advantages result since the energy is released in intermittent fashion and as much as one thousand times greater than in continuous glow.

Also, it is known that materials absorb radiation more efficiently at certain wave lengths than at others. It is difficult to find suitable chemical accelerators which are efficient as accelerators and as absorbers when the radiating wave lengths are restricted to line emissions which may be in positions of the spectrum at some distance from those at which the accelerator is highly absorbtive and hence highly activated. This condition is remedied when the radiating energy is in the form of continuous spectra as opposed to line spectra.

Hence the invention resides in bringing into combination the means for utilizing these two great advantages to meet the needs imposed by modern design which is in quest of higher speeds and which therefore materially shortens the setting times for responsive coating compositions and marking materials.

In further explanation of the invention, it can be pointed out that satisfactory hardening and drying results have been secured on printing inks wherein the non-aqueous, quick drying vehicle for the inks contained the following ingredients in the proportions as given:

	Percent
Raw tung oil	64.0
Methymethacrylate	6.8
Divinylbenzene	4.5
Acrylamide	1.8
Methanol	1.8
Acriflavine	0.05
Stannous chloride	0.006
Methylcellosolve acetate	15.0
Benzoyl peroxide	2.0
Naphthalene sulfonyl chloride	4.0

The flash lamp contained krypton with the capacity of the condenser bank being approximately 350 micro-farads at 1000 volts direct current. Under these conditions the

flash was ascertained to exist for about 700 micro-seconds, releasing energy on each flash of approximately 175 joules. The inks were completely dried upon receiving 12 flashes with the lamp being spaced about 1 inch from the print receiving surface.

In another test wherein entirely satisfactory results were secured, the vehicle for the printing ink had the following formula:

	Percent
Bodied tung oil	86
Toluene diisocyanate adduct with propylene glycol	10
Cinnamoyl chloride	4

The flash lamp in this test contained krypton and mercury and the capacity of the condenser bank was 350 micro-farads with a direct current voltage of approximately 2000 volts. The length of the flash was ascertained to be about 700 micro-seconds and 700 joules energy was released on each flash. The ink dried completely on 9 flashes with the lamp spaced 1 inch from the paper.

Using the same lamp and with the voltage of the power source remaining the same but with only 250 micro-farads of capacity, another test was conducted on an ink having a vehicle containing the following ingredients:

	Percent
Polyester resin	67
Styrene	29
Naphthalene sulfonyl chloride	4

The flash existed for 500 micro-seconds, releasing 500 joules on each flash and requiring only 2 flashes to dry and harden the ink. Even more rapid drying was secured when the voltage was increased to 3500 volts since one flash only was required and which released approximately 1530 joules energy.

An aqueous type of printing ink was also tested wherein the vehicle for the ink had a composition as follows:

	Percent
Acrylamide	42
Water	58
Riboflavin	0.005

In this test the lamp also contained krypton and mercury but the capacity of the condenser bank was increased to 350 micro-farads at 2000 volts direct current. The flash length was ascertained to be 700 micro-seconds, releasing 700 joules energy and requiring 3 flashes to completely dry and harden the ink.

Drying oils containing conjugated unsaturation are susceptible to photosetting action by radiation with light rich in ultra violet rays. For example, tung oil will polymerize readily because eighty percent of its unsaturation is in a conjugated formation. The polymerization is generally described as a chain reaction and improvements have been noted in the rapidity of said chain reactions when the drying oils are compounded with a polymerizable unsaturated monomer and possibly with a selected catalyst. Probably less than thirty or thirty-five percent conjugated unsaturation in a vehicle would not produce a chain reaction suitable for the present purposes and the preferred vehicles are those having at least twelve carbon atoms in the molecule. Thus the invention combines the chemical photosetting properties of such compounds with the physical characteristics of preferred sources of radiant energy when operated in the most efficient manner. The lamps herein contemplated emit a high-energy light. It is of a continuous nature or spectrum and the energy of the emitted light is further increased by the condenser action in flashing the lamps.

What is claimed is:

1. In apparatus of the character described, the combination with moving sheet-like material having a responsive coating in the form of a thin film on the surface thereof, of a lamp providing a source of light characterized by the continuous nature of its spectrum and said lamp having the capability of emitting rays including the ultraviolet ranging from a wave length of 4000 angstroms to 1800 angstroms, means supporting said lamp in close proximity to the surface of said material for irradiating the responsive coating on the same, power means in electrical connection with the lamp, capacitance means in electrical association with said power means and with said lamp, a triggering circuit for the lamp, and means controlling the action of the triggering circuit to effect an instantaneous discharge of the capacitance means through the lamp to cause the same to flash with an energy release of not less than 100 joules per flash, said means including switch structure capable of flashing the lamp at a frequency ranging from not substantially less than 1 to 120 per second.

2. Apparatus of the character as defined by claim 1, wherein the duration of the flashes may range from 50 micro-seconds to 2600 micro-seconds.

3. In a method of rapidly drying and hardening a responsive coating composition in the form of a thin film on a suitable support in the form of a web adapted to have movement, the steps which include producing flashes of energy in the form of electromagnetic radiations at a frequency ranging from not substantially less than 1 to 120 per second and with an energy release of not less than 100 joules per flash, said radiations predominating in ultra-violet rays and being characterized by the continuous nature of its spectrum, and in directing said electromagnetic radiations onto the film to irradiate the same.

4. In a method of rapidly drying and hardening a responsive coating composition in the form of a thin film and containing a quick drying vehicle having as one ingredient thereof a drying oil of the unsaturated conjugated type and wherein approximately thirty percent by weight of its unsaturation is in said conjugated form, the steps which include producing flashes of energy in the form of electromagnetic radiations at a frequency ranging from not substantially less than 1 to 120 per second and with an energy release of not less than 100 joules per flash, said radiations predominating in ultra-violet rays and being characterized by the continuous nature of its spectrum, and in directing said electromagnetic radiations onto the film to irradiate the same.

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